# United States Department of Agriculture,

## FOREST SERVICE,

GIFFORD PINCHOT, Forester.

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## INSTRUCTIONS FOR MAKING FOREST MAPS AND SURVEYS.

It is important that the map work of the Forest Service be uniform in all its features. To this end each member of the Service is directed to observe the following instructions strictly. The directions for making maps and surveys are based upon the experience of the Geological Survey and will be found entirely practical. It is recognized, however, that the scheme for indicating the character of the forest is novel and may need modification. Field men will, nevertheless, follow the instructions and give the plan a thorough trial, though the Forester will welcome suggestions for its improvement.

### SURVEYS.

The purposes of surveys which the members of the Forest Service may be called upon to make are various, but they may be grouped into two classes: (1) The preparation of maps; (2) the running of lines or the rerunning and recovery of old lines.

For the preparation of maps the plane table is almost the universal instrument. For the running of lines various instruments may be employed—the hand compass, the prismatic compass, the staff or tripod compass, the transit, according to the degree of accuracy required. *Test your instruments frequently and be sure they are right.*

### MAKING MAPS.

From the surveyor's point of view, a map is a sketch controlled by points located by means of instruments. Upon the finished map, as we see it, everything is sketched, but the sketch is always referred to and corrected by located points. For instance, the bends in the roads and streams are located, but the roads and streams between the bends are sketched. The points on or near the contours which show the altitudes are located and the contours sketched with reference to them.

There are commonly in use two methods of locating points; one is

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the method of triangulation, by which the location of a point is obtained by the intersection of two or more sight lines measured from points already located; the other is the measurement of a direction and a distance. A plane table is used in both these methods.

### THE PLANE TABLE.

The plane table in common use consists of a board mounted on a tripod. In the head of the tripod is an adjustment for leveling the board and for turning it horizontally, with separate clamps for holding it in level and in direction. Upon the board is fastened by thumbscrews a sheet of drawing paper, upon which the locations are to be made and the map drawn.

The instrument used in connection with the table is the alidade. It is essentially a steel ruler, firmly attached to which is a vertical column carrying a telescope whose axis is parallel to the edge of the ruler. Thus, if the telescope is sighted upon an object and a line drawn along the edge of the ruler, that line will point directly toward the object. Within the telescope are one vertical and three horizontal wires. The vertical wire must be laid upon the object sighted; the horizontal wires are for measuring distances and vertical angles, as described later.

Before commencing to use the alidade it should be carefully tested. For testing horizontal collimation (alignment) the vertical wire should be sighted upon some vertical object, such as the corner of a house or a signal pole; then, without moving the alidade, the telescope should be turned around 180° in its sleeve. If the vertical wire still remains on the object, no horizontal adjustment is required. If, however, it is not upon the object, the wires must be moved by means of the small screws just in front of the eyepiece until the collimation is perfect. The wire should be moved one-half of the apparent error.

The adjustment for vertical collimation is similar, except that the middle horizontal wire must be placed upon some horizontal line, such as the ridge of a house, and the test made upon this by turning the telescope halfway round in its sleeve. If correction is necessary, it can be made in a similar manner by moving the screws at top and bottom.

### USING THE PLANE TABLE.

To describe the use of the plane table, it will be best to take an example. Suppose we wish to survey a certain tract of ground of half a dozen square miles. The first thing to be done is to select triangulation points all over the area. These points should be visited and signals (poles and flags) erected upon them, except in cases where suitable points for signals already exist, such as a church spire, a chimney, a corner of a house, or a prominent tree. In these cases the

erection of a signal will not be necessary. The number of points selected will be determined by the degree of accuracy sought. The more points to and from which sights are made, the more exact is the map.

The next thing is to measure a base line. A site for this should be selected which is as nearly level and free from obstructions as possible, and where one end can be seen from the other. A piece of railway track is the best location, and next to that, a straight piece of road. For such an area a base perhaps 2,000 to 2,500 feet long will be sufficient. This should be measured very carefully with a steel tape, using a 100-foot tape if practicable. In measuring a base on the ground the tape ends should be marked with case knives instead of surveyor's pins; if on a railroad the tape ends should be marked by scratches on the rails. If the base is not level its length must be reduced to a horizontal line by computation.

Then a line should be drawn upon the plane-table sheet representing this base and having the proper length in accordance with the scale of the map to be made. If the scale is to be 1,000 feet to the inch, and the base line is 2,500 feet in length, the line representing it would, of course, be 2½ inches in length. The two ends of the base should be marked on the paper by holes pricked with a fine needle. The plane table should then be set up over one end of the base line, while at the other end should be placed a pole, with a flag to serve as a signal. When the plane table is set up over the end of the base the point upon the paper representing this end of the base should be directly over the stake. This can be determined by hanging a plumb bob under the table and moving the latter until the plumb bob is over the stake. Then the table must be leveled and clamped in level. The ruler of the alidade is next laid along the line representing the base, and the table is turned horizontally until the signal at the other end of the base is directly in line with the vertical wire in the telescope. The table is now oriented and should be clamped in this position. Then, keeping the edge of the ruler upon the point representing the beginning of the base line, the telescope should be directed in turn to each of the signals, and lines drawn in their directions. Upon each line should be noted the object to which it is directed.

When lines have thus been drawn to every signal in sight the table should be set up at the other end of the base, a signal erected at the first end, and the operation repeated. The intersection of the lines drawn from this station with those drawn from the first station will mark the locations of the points.

Certain of the points thus established should be visited in turn and occupied as plane-table stations in a similar manner until all points upon the area under survey, of which it is desirable to obtain the position, have been located.

In this work of triangulation it is essential that the utmost accuracy be obtained. A hard pencil sharpened to a fine edge should be used for drawing lines, and the ruler of the alidade should be placed directly over the center of the mark indicating the position of the station. A slight error in the location of any one point will accumulate in those determined from it, and the errors will soon become so large that the work will be worthless.

THE STADIA.

In working upon large scales it is well to use the stadia for locating points of secondary importance, and especially in making the numerous locations necessary for sketching contours. The stadia are the upper and lower horizontal wires in the alidade. These wires are adjusted for measuring distances in connection with a board 6 inches wide and 13 feet long called the stadia rod, which is graduated in alternate white and black bands. One or two of these bands are further subdivided into tenths. Each full space on the board corresponds with a horizontal distance of 100 feet. In use this board is placed upright at some distance from the instrument, and the telescope is pointed upon it. The space upon the board which is embraced between the two wires tells the distance at which the board stands. Thus, if the wires embrace five spaces on the board, the latter should be 500 feet away; if ten spaces on the board, it should be 1,000 feet away.

As with all instruments, the stadia wires must be tested with the board, and if found wrong the spaces on the board must be increased or diminished, so that five spaces measure 500 feet, etc.

If therefore we wish to measure the distance and direction of an object we send a rodman with this board to that point. He holds the board vertically upon it, and by reading the number of spaces subtended by the stadia wires the distance in hundreds of feet is read off. A line is then drawn along the ruler of the alidade, and the indicated distance is marked on that line, thus giving the location of the point. By the use of two rodmen locations of this sort can be made very rapidly. Stadia measurements should be made from each triangulation station, in addition to locating the points.

It is important that the graduated board be held perfectly vertical, otherwise the spaces are shortened and the measurement made inaccurate. Distances measured upon a slope must be reduced to the horizontal distance whenever the correction is sufficiently large to appear upon the scale of the map. Tables giving this correction will be furnished.

ELEVATIONS.

The elevations of all points located, whether by triangulation or by stadia, should be measured, and for this purpose the vertical arc of the alidade is used. Before making such a measurement the telescope

of the alidade must be leveled by means of the striding level. To determine an elevation the telescope is first inclined until the middle horizontal wire just touches the top of the object on which it is sighted, when the vertical arc is read. The telescope is then leveled by means of the striding level and the reading of the vertical arc again taken. The difference between the two readings is the angle of inclination between the instrument and the object sighted. It is plus if the first reading is the greater, and minus if the second reading is greater. That is, plus if the object sighted is higher than the station, minus if it is lower. The distance to the object as recorded upon the plane-table sheet is then measured, and with the distance and the angle the difference in the height is taken from the accompanying tables. These tables give the height for all angles and distances, corrected for curvature of the earth, refraction, and height of instrument. When points are located by the stadia, the instrument should be sighted, not to the ground, but to a point on the stadia rod 4½ feet from the ground, in order to avoid making a correction for the height of the instrument.

## SKETCHING IN.

The location of the various points and their elevations having been determined, the next thing is the process of sketching in. Some of this may be done as the location of the points proceeds. Thus the different points located upon roads and streams may be connected by lines representing them. As a rule, the contours will have to wait until after the locations are completed. The map will then be covered with dots showing the located points, with the elevation of each written alongside of it. With this skeleton of a map the surveyor then travels about over the country and sketches in the contours and other data with reference to these locations and heights. Suppose, for instance, we are putting in 10-foot contours; we have measured the top of the hill, 100 feet high, and its base on the side nearest us is 20 feet. The slope of the hill is gradual near the summit, then becomes steeper, and near the base again becomes gentle. The contour of the 60-foot line will probably be about half-way between the location at the top and at the base, but, in order to represent the gradations of the slope, those representing 50 and 70 feet will be nearer the 60-foot contour than the 90-foot contour is to the summit contour; and the 30-foot contour will be farther away from the base 20-foot contour. Going on around the hill we find that in one place a spur runs out with a gentle slope from the summit, while from the head of the spur there is a steep descent to the valley. The head of the spur should be located and its height measured. Such a measurement may show that there is a descent of about 30 feet to the head of the spur, leaving 70 feet from the head to the valley.

The selection of points for location is a matter of great importance,

because by judicious selection fewer points can be made to serve the purpose than would be the case with a bad selection. For instance, if we are locating a road it is necessary only to locate the bends of the road, for it is a waste of time to locate points upon it where it is straight, and the same is the case with streams. For locating contours it may be sufficient, in case the slope is regular, to locate the top of a hill and its base and space in the contours upon its slope in proportion to the degree of slope. If, however, the slope is irregular it may be necessary to locate several points from top to bottom in order to space in the contours accurately.

As a rule it is not advisable to attempt to find points upon the actual contours and locate them, but it is better to locate points and measure their height and then space in the contours relatively to them. Where the country is very level, however, it may be economical to trace the contours out.

### RUNNING LINES.

For running lines a compass instrument is always used. The transit is the most accurate and the prismatic or hand compass the least. The tripod or staff compass is very commonly used and gives results sufficiently accurate for most purposes.

For running traverses, mapping the course of roads, trails, and streams, the light, traverse plane table used by the Geological Survey is the best instrument. This consists of a board mounted on a light pine tripod without any leveling device. In the edge of the board is set a compass in a narrow box. In the place of an alidade is a short ruler with raised sights. The table is oriented by turning it until the compass needle points to the marks at the middle of each end of the box. Commonly in this work a rodman is dispensed with, and sights are made on points along the road. Usually distances are determined by pacing or, if driving, by counting the revolutions of the buggy wheel, but wherever accuracy is desired they should be chained.

It is not well to run traverses by deflection angles, with either theodolite or plane table, since the errors in direction will soon accumulate greatly.

In traversing a road or trail for the purpose of adding it to a map, it is necessary to connect it with points already located upon the map, in order that it may be placed in its proper position. Intersections should be obtained upon hills, near the line of the road, and upon houses and other landmarks which appear on the map, and then the map of the road can be properly fitted in.

In such work as this it is not necessary to take account of the magnetic variation, that is, the angle which the compass needle makes with the true north direction. It often is necessary to take account of this, as in running lines in certain directions or in retracing old

lines. Tables giving the magnetic variation in all parts of the country for the year 1900 have been published by the United States Geological Survey, and for 1905 by the United States Coast and Geodetic Survey. Either of these can be used, preferably the latter. In using the tables it must be understood that where the variation is stated to be east the compass needle points east of the true north. The line along which there is no variation runs at present through eastern Maryland. East of that line the variation is west, that is, the needle points west of the true north; and west of that line—that is, in nearly all of the United States—the variation is east.

In running old lines there is another factor besides magnetic variation which must be accounted for, that is, what is called secular variation. At the same place the compass needle does not always bear the same relation to the true north, but changes year by year; and that change is not uniform in different parts of the country, but differs in amount in different places. At present the east magnetic variation is increasing by from 1 to 4 minutes each year, and the west variation is diminishing by similar amounts. Tables published by the Geological Survey give the amount of this annual change in different parts of the country. By applying them, the variation in any place at the time the old survey was made can be obtained, and the corresponding correction made in order to reestablish the direction of the line at present. Thus, if we find the present variation at a certain place to be 10 degrees east, while the annual change is 3 minutes, and the early survey was made 50 years ago, the compass variation that must be used in order to trace the old line is 10 degrees, minus 3 minutes multiplied by 50 years, or 7° 30′. If we assume, therefore, that the old survey was accurately run, the old line will be retraced by running with this variation.

Township and section lines of the land surveys are run on the true north, east or west, and usually by solar compass. In rerunning them it is necessary only to correct for the present variation of the needle.

In running any survey with the compass, the readings are sometimes wrong as a result of local magnetic attraction due to the presence of magnetic iron ore or of iron in the vicinity. When running a line with a compass, backsights should be taken occasionally, in order to determine whether local attraction exists.

## THE ANEROID BAROMETER.

In many kinds of forest work there will be frequent need for measuring the approximate heights of points, and for this purpose the aneroid barometer is a very useful instrument. Its limitations must be understood, however, and it should never be used for purposes to which it is not adapted. It is not accurate in the highest sense, since

it can be read only to 20 feet. It is uncertain, and if trusted too far is very apt to give misleading results. It should not be used, except in a rough way, to measure any great differences of altitude. Where the difference of altitude exceeds 1,000 feet it is liable to result in errors. The foot scale only should be used—the inch scale should be disregarded. It should be compared as frequently as possible at some known elevation; certainly every morning and evening. On commencing the day's work the foot scale should be set to the elevation at a known place; then the instrument may be read through the day for the measurement of heights, but on returning it should be again compared, and, if there is a decided difference between the morning and evening comparisons, a sliding correction should be made to the heights measured during the day.

## STAND AND TYPE MAPS.

Data relative to the character and condition of the forest, and to nonforest areas, in a given region, will be shown upon a base map of some kind. If a printed map is available it should be used; if not, topographic and forest features can be noted at the same time.

The following directions are intended to afford the means of making clear, comprehensible, and uniform forest maps. Only by adhering strictly to them can the desired results be obtained.

The scheme is based upon a series of symbols and colors, each one of which means a definite thing. When the symbols are properly used on a topographic map or sketch, they will furnish a clear picture of the forest and its components. To carry out this scheme a box of pencils is supplied, nine of which are colored and three are black, of different grades. Each color to be used may be identified by the number or letter stamped on the pencil. Care should therefore be taken to sharpen the other end.

### THE FOREST.

Wherever trees are found, each species will be shown by the *symbol* and *color* indicated below, and the approximate quantity by a figure expressing thousand feet per acre. Thus △ 6 R 4 S 3 means that the stand is 6,000 feet of white oak, 4,000 feet of yellow poplar, and 3,000 feet of black cherry if all the symbols are crimson (75). If the △ only is crimson (75), the R brown (43), and the S light green (63), it means that the stand is 6,000 feet of white oak, 4,000 feet of basswood, and 3,000 feet of beech. As a rule it will not be necessary to distinguish the various white oaks, nor the black oaks, nor some of the junipers, hickories, etc. If it is necessary to indicate other species than those named, make the proper symbol in a color that is not appropriated, or that is used in another region exclusively, and state in the accompanying text that you have done so. For instance, if you want to show Cuban pine and pond pine on a long-leaf tract, use the symbols for white pine and red pine. The purpose of this plan is to simplify

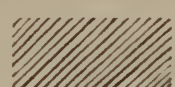
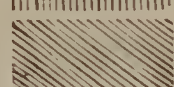
forest description, not to complicate it, and species need be recognized only when they occupy an individual position silvically. Scrub oaks, juniper, rhododendron, and other trees whose quantity can not be expressed in board feet may be set down as *scattered* or *thicket*.

### OPEN LAND.

Nonforest areas, burns, etc., will be indicated by solid colors and lines as follows: A burn on cut-over land, or a windfall, may be shown by combining the two kinds of hatching.

### SYMBOLS.

(In all cases the numbers in parentheses are those that will be found on the pencils.)

Light blue (88), water.
Yellow (2), open grazing land and various species.
Orange (62), agricultural land and various species.
Gray (H), desert land and various species.
Red lines (38) , cut-over land and various species.
Black lines (H) , burn.
Black lines (H) , windfall.
Brown (43), various species.
Crimson (75), various species.
Dark blue (12), various species.
Dark green (69), various species.
Light green (63), various species.

White pine (69) ●
Red pine (75) ●
Jack pine (H) ●
Longleaf pine (63) ●
Shortleaf pine (43) ●
Loblolly pine (62) ●
Pitch pine (38) ●
Scrub pines (2) ●

Western yellow pine (H) ○
Jeffrey pine (63) ○
Lodgepole pine (75) ○
Sugar pine (38) ○
Silver pine (62) ○
Piñon pines (2) ○
Alpine pines (43) ○
Desert pines (43) ○
Monterey pine (43) ○
Black spruce (43) —
Red spruce (62) —

White spruce (63) —
Blue spruce (75) —
Sitka spruce (69) —
Engelmann spruce (H) —

Balsam fir (62) +
Fraser fir (63) +
White fir (38) +.
Lowland fir (69) +
Noble fir (43) +
Amabilis fir (H) +
Alpine fir (75) +
Cal. Red fir (2) +

Tamarack (69) V
Western larch (62) V
Alpine larch (43) V
Monterey cypress (62) ∗
Bald cypress (63) ∗
Big tree (38) ∗
Redwood (75) ∗

Red fir (69) ∗
Big cone spruce (H) ∗

Hemlock (62) H
Carolina hemlock (63) H
Western hemlock (69) H
Black hemlock (43) H

Arborvitæ (75) Z
White cedar (38) Z
Giant arborvitæ (69) Z
Incense cedar (H) Z
Port Orford cedar (63) Z
Yellow cedar (2) Z

Desert cedars (62) T
Red juniper (63) T
Western juniper (H) T
One-seed juniper (2) T

Swamp ashes (63) ↑
Highland ashes (75) ↑

Swamp hickories (75) □
Highland hickories (75) ■

White oaks (75) △
Black oaks (75) ▲
Chestnut oak (43) △
Live oak (69) △
Tanbark oak (38) △
Red oak (43) ▲
Black jack oak (63) ▲
Scrub oaks (2) ▲
Red gum (63) ⊏
Black gum (75) ⊏

Tupelo gum (12) ⊏

Sugar maple (63) Y
Red maple (62) Y
Silver maple (75) Y
Oregon maple (69) Y
Boxelders (12) Y

Yellow poplar (75) R
Basswoods (43) R
Magnolia (63) R
Buckeyes (69) R
Rhododendron (62) R

Elms (75) W
Hackberries (63) W
Yellow or sweet birch (43) W
White or paper birch (69) W

Black walnut (75) ∩
Butternut (63) ∩
Chestnuts (43) ∩
Locusts (62) ∩
Mulberry (12) ∩

Black cherry (75) S
Wild red cherry (69) S
Beech (63) S

Aspens (69) Φ
Cottonwoods (H) Φ
Sycamores (75) Φ
Alders (43) Φ
Willows (12) Φ

Mesquites (2) P
Chaparral (H) P

In using these symbols care must be exercised that areas of the proper size are considered as units. The general rule should be to define each piece according to its natural character. If the map refers to hardwood country, bottom, slope, and ridge will be distinguished by the topography and the species indicated on each; if to pine lands, hummock, swamp, and flat will probably be the types. In some cases it may be best to take a compartment or block as the unit, but over-exactness is to be avoided as well as too much generalization.

Approved, August 10, 1905.

James Wilson,
*Secretary.*

Washington, D. C., *October 5, 1905.*